Space Weather Forecasting

Measurement and Modeling Requirements

Living with a Star Measurements Workshop
NASA Goddard Space Center

February 9-10, 2000

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NOAA Space Environment Center

SEC Users

Aviation Aerospace industry Biological systems Educa

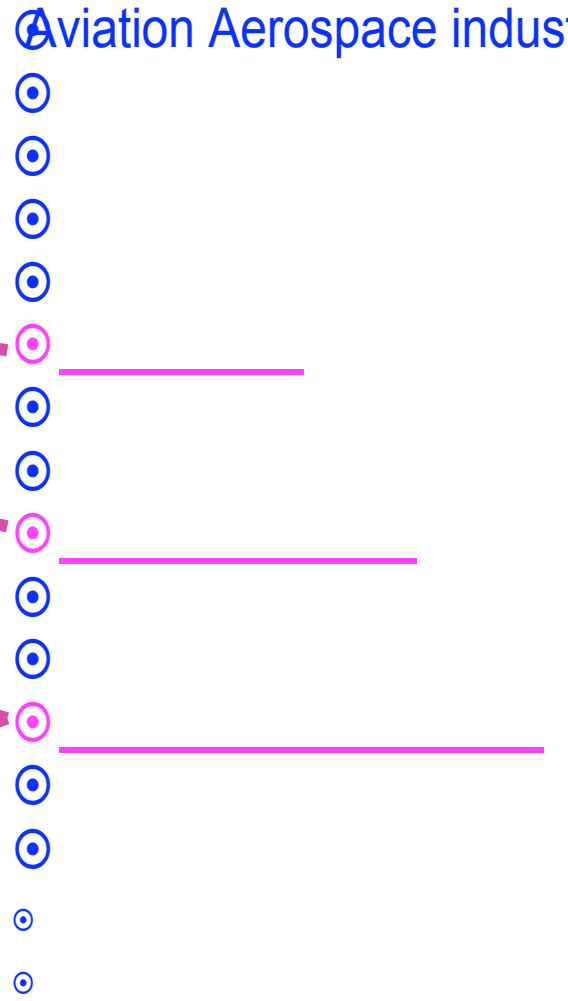
Space Weather Domain

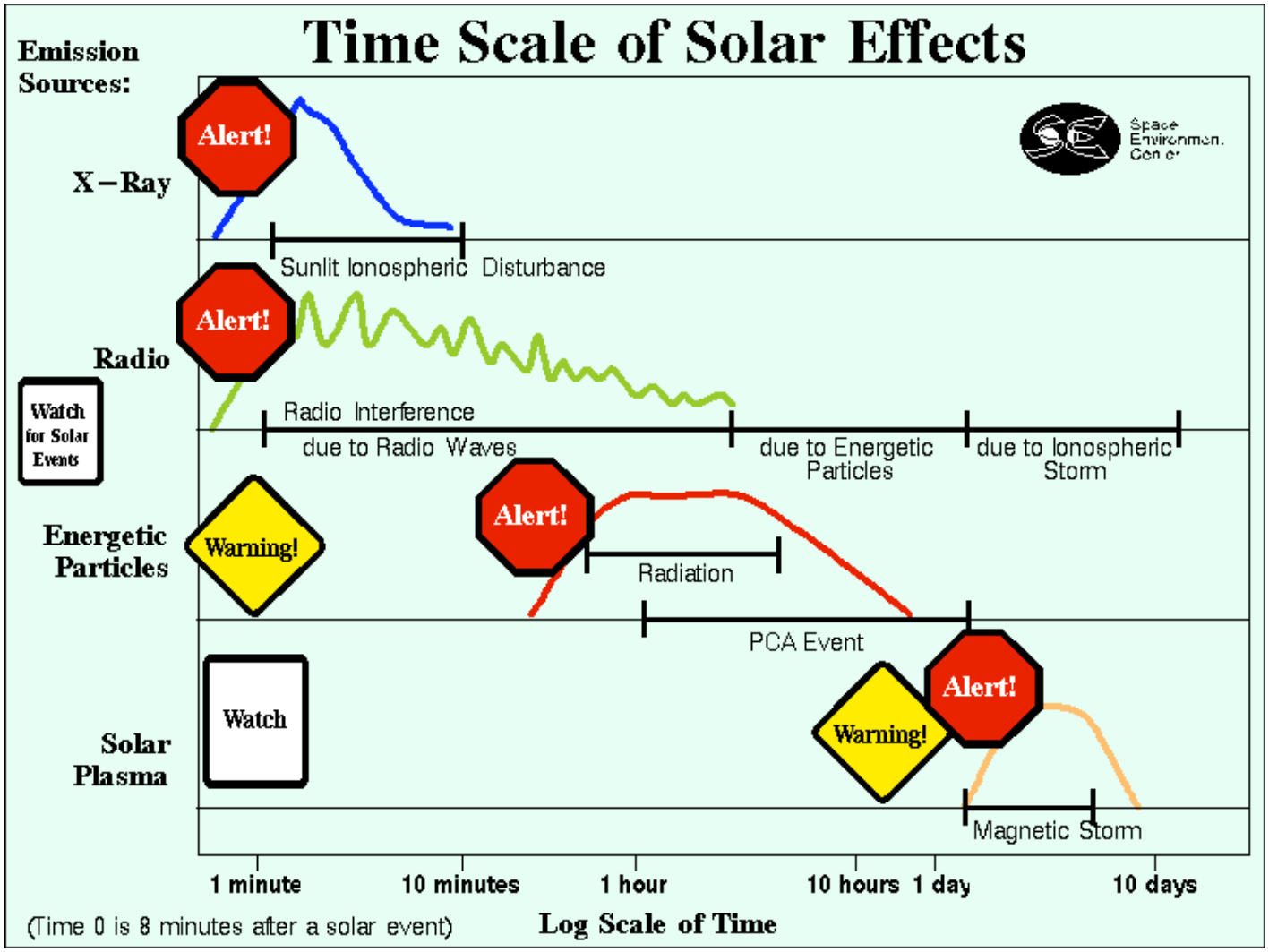
Ionosphere

Geomagnetic field

Atmospheric density

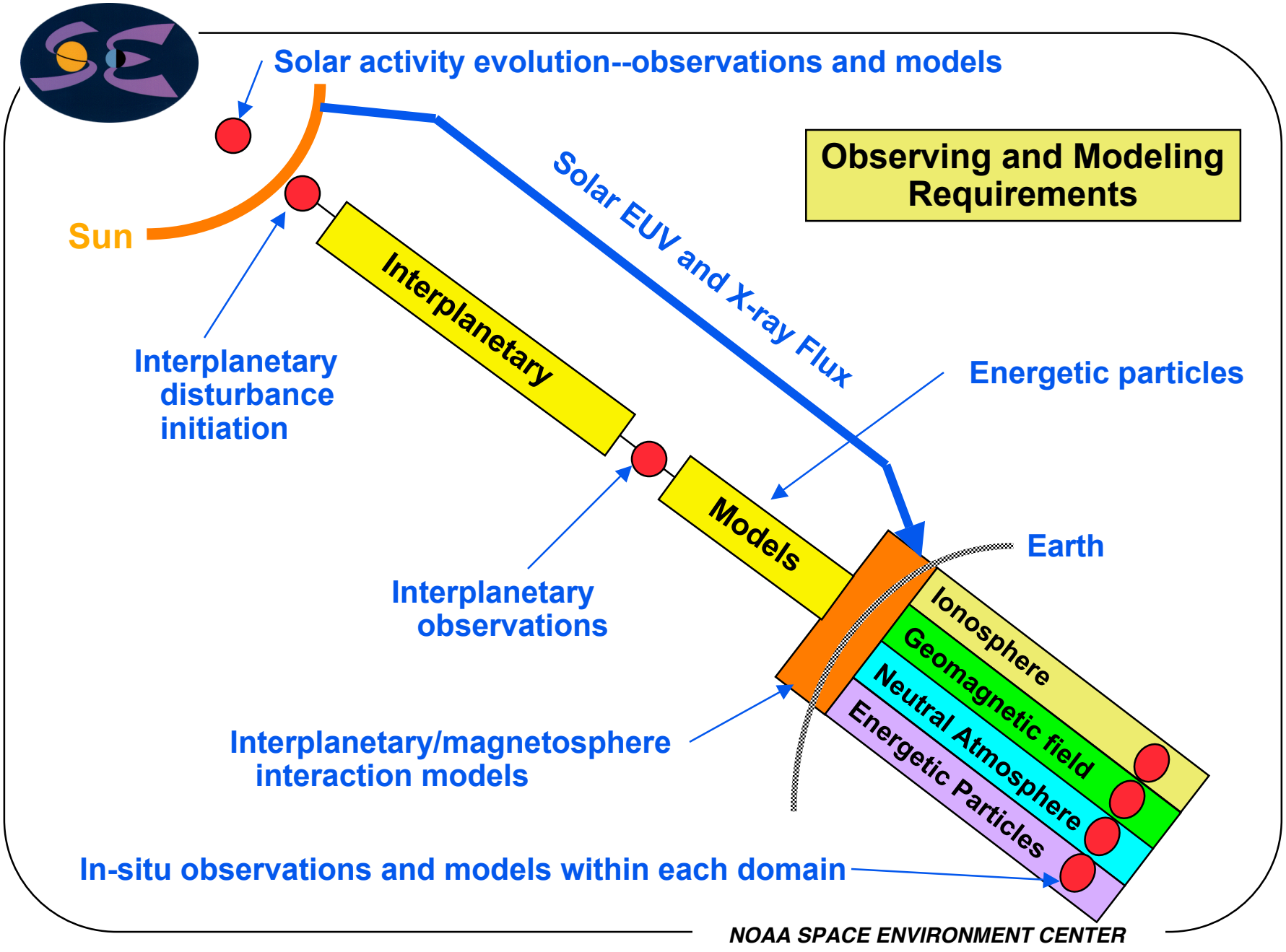
Energetic particle environment




Time Scale of Solar Effects
Emission Sources:
X−Ray
Alert!
Sunlit Ionospheric Disturbance
Radio
Alert!
Watch for Solar Events
Radio Interference due to Radio Waves
due to Energetic Particles
due to Ionospheric Storm
Energetic Particles
Warning!
Alert!
Radiation
PCA Event
Solar Plasma
Watch
Warning!
Alert!
Magnetic Storm
1 minute
10 minutes
1 hour
10 hours
1 day
10 days
(Time 0 is 8 minutes after a solar event)
Log Scale of Time
Space Environmen. Cen er

Products

- Forecasts (text and models) (1-3 days, month, years)
- Alerts (right now)
- Warnings (up to one hour)
- Watches (up to one hour)
- Advisories
- Specification (text and models) (right now)
- Measurements and indices (right now to a few hours)


Solar activity evolution--observations and models
Observing and Modeling Requirements
Sun
Solar EUV and X-ray Flux
Interplanetary
Interplanetary disturbance initiation
Energetic particles
Models
Earth
Interplanetary observations
Ionosphere
Geomagnetic field
Neutral Atmosphere
Energetic Particles
Interplanetary/magnetosphere interaction models
In-situ observations and models within each domain
NOAA SPACE ENVIRONMENT CENTER

Verification is a critical function

Forecasting Geomagnetic Storms Verification

Currently

Observed

Forecast	No Storm	Storm
No Storm	2498	59
Storm Ap' > 50	38	20

One-day Forecasts; 1989 – 1995

with ACE

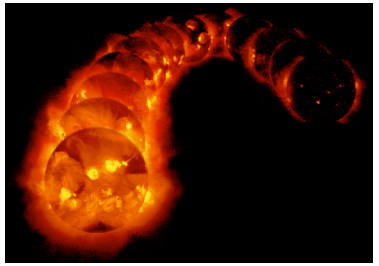
(real-time solar wind data)

Observed

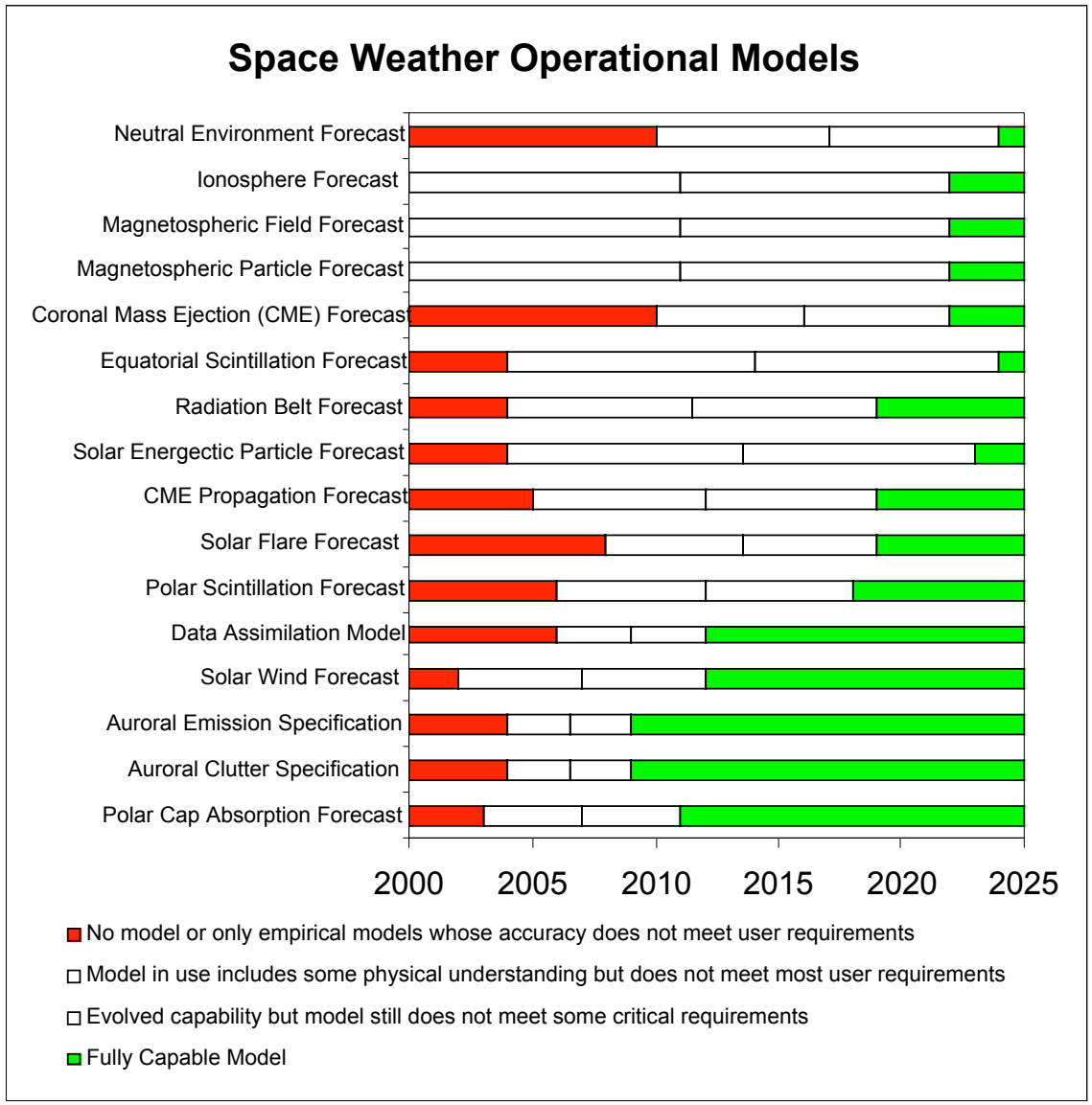
With Warning	No Storm	Storm
No Storm	2498	~0
Storm Ap' > 50	~0	79

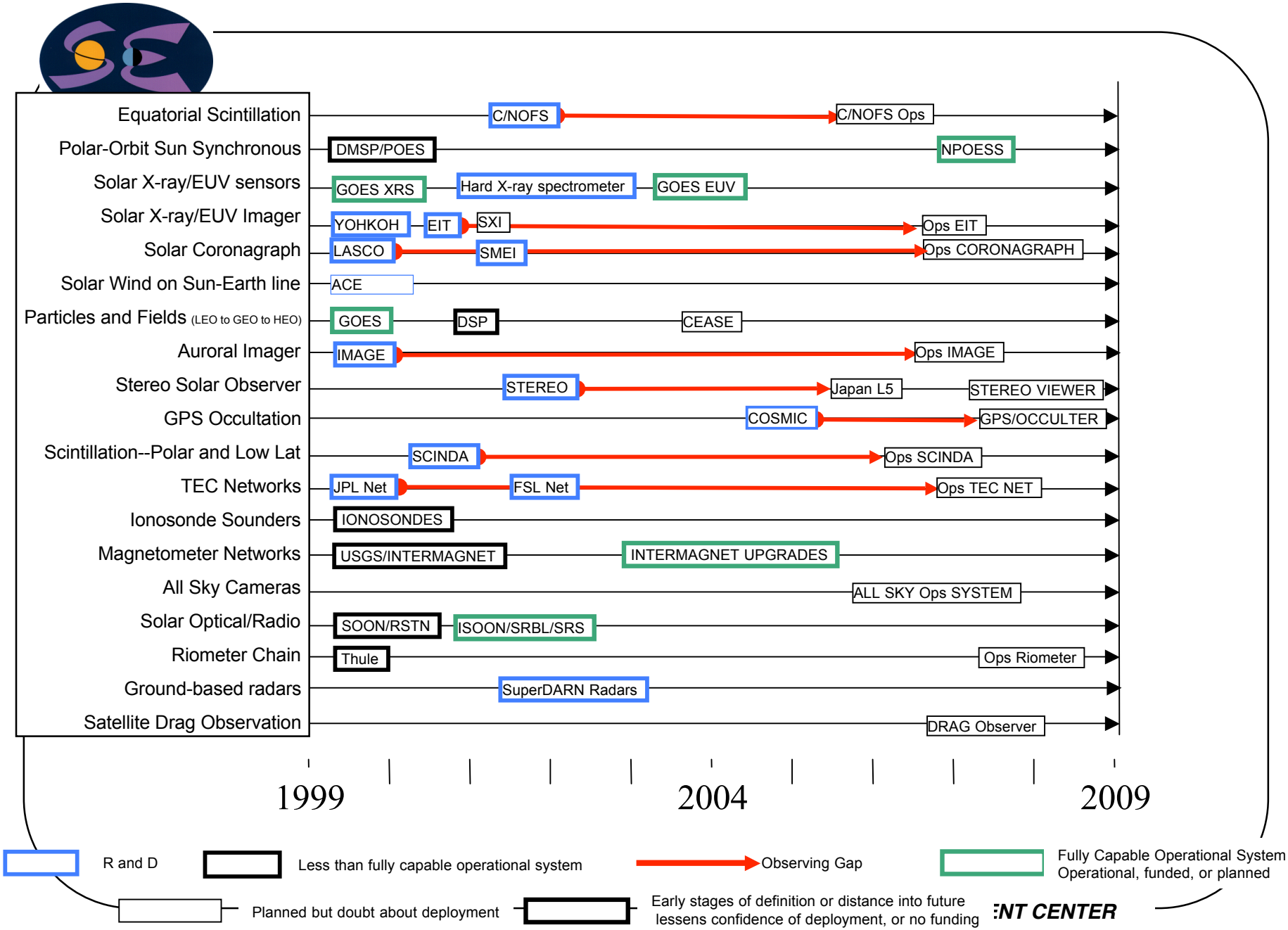
One-hour Warnings; Expected

Solar Measurement Priorities

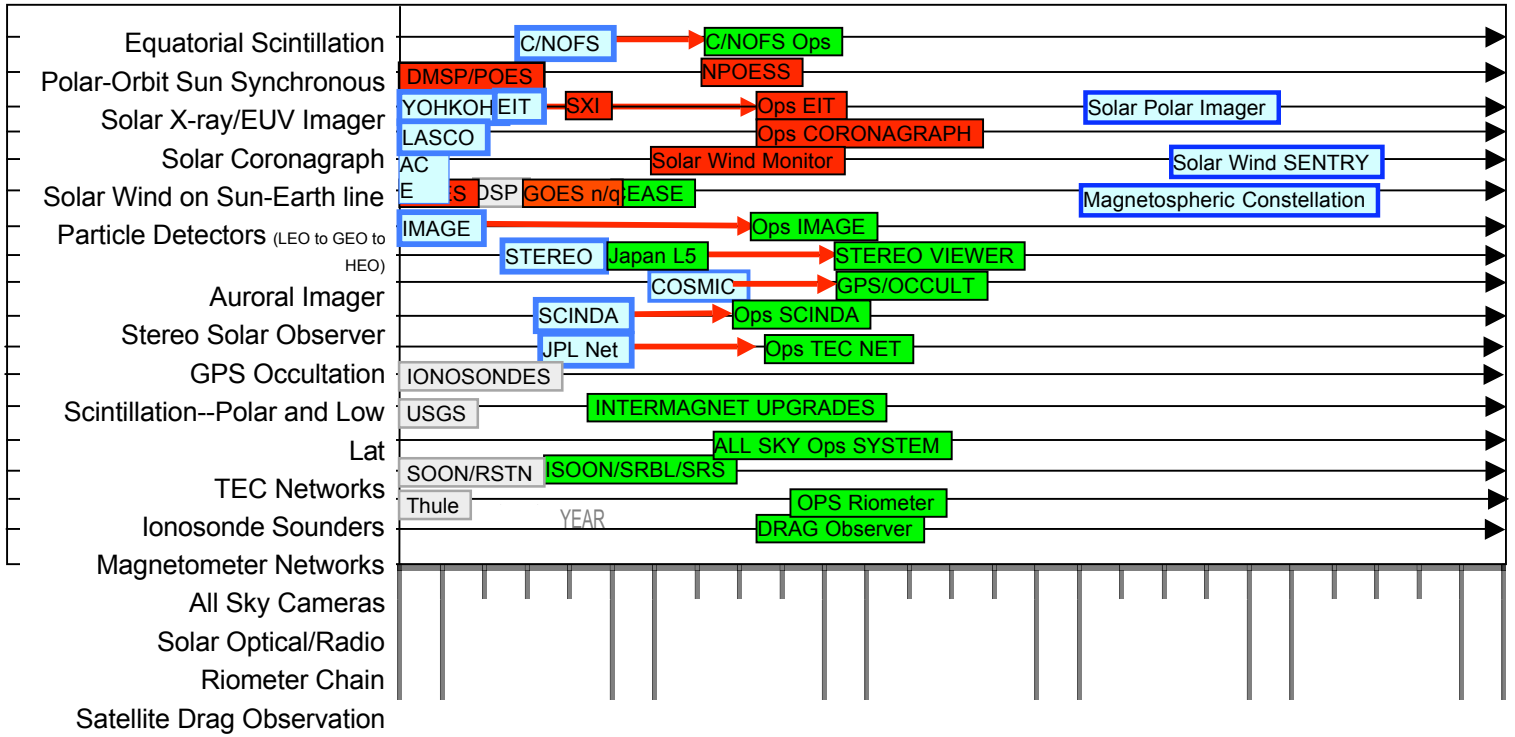


- CME initiation in 3 dimensions to drive interplanetary models
  - Direction
  - Radial velocity
  - Structure and configuration
- Coronal Holes—observation and prediction of Earth impact
- EUV/X-ray flux—observation and prediction
- Evidence of energetic particle acceleration and interplanetary injection
- X-ray flares and radio bursts—observation and forecasting
- Evolution of active structures--prediction
- Cycle evolution--prediction


Space Weather Operational Models
Neutral Environment Forecast
Ionosphere Forecast
Magnetospheric Field Forecast
Magnetospheric Particle Forecast
Coronal Mass Ejection (CME) Forecast
Equatorial Scintillation Forecast
Radiation Belt Forecast
Solar Energectic Particle Forecast
CME Propagation Forecast
Solar Flare Forecast
Polar Scintillation Forecast
Data Assimilation Model
Solar Wind Forecast
Auroral Emission Specification
Auroral Clutter Specification
Polar Cap Absorption Forecast
2000
2005
2010
2015
2020
2025
No model or only empirical models whose accuracy does not meet user requirements
Model in use includes some physical understanding but does not meet most user requirements
Evolved capability but model still does not meet some critical requirements
Fully Capable Model


Equatorial Scintillation
C/NOFS
C/NOFS Ops
Polar-Orbit Sun Synchronous
DMSP/POES
NPOESS
Solar X-ray/EUV sensors
GOES XRS
Hard X-ray spectrometer
GOES EUV
Solar X-ray/EUV Imager
YOHKOH
EIT
SXI
Ops EIT
Solar Coronagraph
LASCO
SMEI
Ops CORONAGRAPH
Solar Wind on Sun-Earth line
ACE
Particles and Fields (LEO to GEO to HEO)
GOES
DSP
CEASE
Auroral Imager
IMAGE
Ops IMAGE
Stereo Solar Observer
STEREO
Japan L5
STEREO VIEWER
GPS Occultation
COSMIC
GPS/OCCULTER
Scintillation--Polar and Low Lat
SCINDA
Ops SCINDA
TEC Networks
JPL Net
FSL Net
Ops TEC NET
Ionosonde Sounders
IONOSONDES
Magnetometer Networks
USGS/INTERMAGNET
INTERMAGNET UPGRADES
All Sky Cameras
ALL SKY Ops SYSTEM
Solar Optical/Radio
SOON/RSTN
ISOON/SRBL/SRS
Riometer Chain
Thule
Ops Riometer
Ground-based radars
SuperDARN Radars
Satellite Drag Observation
DRAG Observer
1999
2004
2009
R and D
Less than fully capable operational system
Observing Gap
Fully Capable Operational System
Operational, funded, or planned
Planned but doubt about deployment
Early stages of definition or distance into future
lessens confidence of deployment, or no funding
:NT CENTER

Space Weather Operational Sensors Timeline



Note: this version of the plan has not incorporated sensors from the NASA-interagency initiative Living with a Star

New Operational Measurement Priorities

- Provide quantities that meet user priorities
- Information to fill weak links in Sun-Earth propagation
- Model drivers
- Information that provides most reliable forecasts or model input has higher rank